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Innovation for the interwar years

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Abstract:
The US Navy developed and fielded new capabilities in the years between WWI and WWII, but the Cold War and subsequent developments have raised the bar for US military peacetime commitments. New naval technology is examined.

Full Text:

[Headnote]

"The unresting progress of mankind causes the continual change in weapons; and with that must come the continual change in the manner of fighting:"1

Between World War I and World War II, the naval service nurtured many warfighting innovationsmost notably carrier aviation and amphibious warfare-that proved decisive in time of war.2 The end of the Cold War has left the United States in what may be another interwar period. In this period of reduced tension, however, the United States must do more than merely prepare to fight and win the next regional conflict. Instead, the expanding international community of free-market democracies requires a security strategy that promotes stability, encourages **economic** growth, and prevents conflict-capitalizing on America's **economic** and military strength all the while.

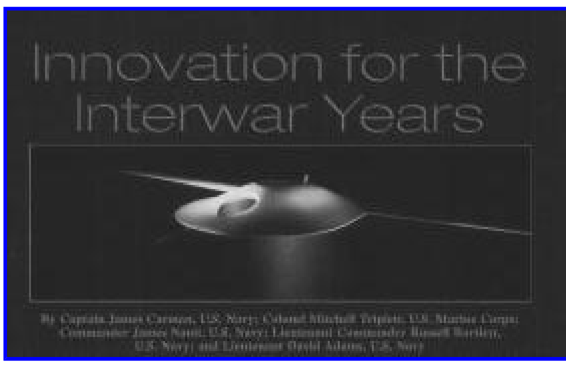
Preparation for war does have some preventive and deterrent value in itself. But in the 21st century, there will be no substitute for U.S. **forward presence**-available at the outset to contain crisis, protect vital interests, provide humanitarian assistance, deter or halt aggression, and bring about joint victory, should deterrence fail. Reduced overseas basing will require the United States and its allies to rely increasingly on **forward**-deployed **naval** forces to maintain a stabilizing influence on international relations. Declining fiscal resources, competing domestic priorities, and rising operational pressures require the **naval** service to embrace innovation in order to ensure the success of U.S. foreign policy.

History has shown that successful military innovation requires sound operational principles to be fused with revolutionary technological developments.3 Today, Forward

. . From the Sea, Operational Maneuver. . . From the Sea, and the recently released The Navy Operational Concept demand revolutionary changes in the way naval forces operate to accomplish national objectives. These operational concepts, however, are empty words on glossy pages-unless the promise of new technology is harnessed to reinforce their revolutionary premise.

Defending the United States' worldwide vital interests requires naval forces to have the ability to prevail in both open-ocean and littoral operating environments. According to The Navy Operational Concept, future naval forces will "deliver integrated joint fires with increased range, lethality, accuracy, and timeliness."4 Projecting power across most of the world's population and **economic** centers implies an extension of the littoral battlespace from the beach inland to 200 miles and beyond. This extension highlights an emerging shortfall in our ability to support highly maneuverable ground forces further inland with affordable-level-of-effort fires at extended ranges. In this context, "level-of-effort fires" implies the sustained delivery-in mass and volume-of munitions on the battlefield.

The need to maneuver naval forces with less predictability while projecting power 200 miles inland requires a cross-range volume of fires capability of about 400 miles. Carrier-based tactical aviation can fill this requirement, but this alternative is not the best employment of our most flexible power-projection asset. An affordable, medium-range level-of-effort weapon could counter this emerging shortfall in level-of-effort fires capability and release carrier-based tactical aviation to conduct strikes against pop-up, mobile, and relocatable targets-particularly when less-than-perfect targeting information is available.



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Development of the extended-range guided munition (ERGM) and vertical gun for advanced ships (VGAS) will increase the intensity of the Navy's level-of-effort capability incrementally in the next decade. These planned improvements will pave the way for a revolution in naval fires through the development of an affordable, mediumrange (25-400 miles), high-rate-of-fire naval weapon. Naval Rail Guns

Recent advances in rail-gun technology offer the most promising option for delivering such a capability. Rail guns use electromagnetic, instead of chemical, energy to accelerate projectiles to hypersonic velocities. To put this capability in perspective, our current 5-inch guns have a muzzle energy of 10 megajoules (MJ). ERGM will increase this to 18 MJ, and VGAS will press the limits of conventional gun physics-attempting to achieve a muzzle energy of 33 MJ. By contrast, a naval rail gun could have muzzle energies in excess of 300 MJ, providing an order-of-magnitude increase over today's naval gunfire capabilities.

Driven by the necessity to penetrate explosive reactive armor, the Army has made a substantial investment in railgun technology for integration into an all-electric main battle tank, scheduled to be operational in the 2015 timeframe. Over the past decade, this investment has improved our understanding of pulsed power, rail design, and electromagnetic launch, making rail-gun technology a feasible military option.5 In fact, rail guns have demonstrated the ability to launch projectiles up to 6 km/sec (Mach 18).

Moreover, recent developments indicate that solutions for the remaining technical challenges-namely, excessive power requirements and rail erosion-are firmly within reach. This is an ideal time to capitalize on Army research and to develop rail guns for naval applications.

Taking advantage of rail-gun technology-or any highenergy weapon system-will require power on the same order of magnitude as that needed for ship propulsion. This power requirement can be met with an all-electric, integrated power system that simultaneously supports the demanding energy requirements of advanced electrical propulsion and high-energy weapon systems. An integrated power system brings many additional advantages, including a 25%-40% life-cycle fuel savings and a fully modularized engineering plant. All-electric, integrated power is key for revolutionizing the fleet's powerprojection capabilities. This technology should be tested and refined with appropriate prototypes, such as the Maritime Fire Support Demonstrator.

A notional naval rail gun could deliver 150-pound, GPS/INS-guided projectiles with an impact velocity of Mach 6 to targets at ranges up to 400 miles at a rate greater than six rounds per minute. Mature rail-gun technology is predicted to produce even greater capability. However, limiting the combination of muzzle velocity, muzzle energy, and range would mitigate the technical risk and maintain manageable development costs.

Rail guns have devastating destructive power. One test demonstrated that the release of the projectile's kinetic energy alone would create a crater ten feet in diameter and ten feet deep, and achieve projectile penetration to 40 feet. Rail guns, however, are not limited to solid kinetic-energy warheads. They could also employ blast fragmentation submunitions or explosives, to engage a wide variety of battlefield targets.

Developing naval rail guns to share or shoulder the level-of-effort burden would allow carrier-based tactical aviation and other power-projection assets to focus on more challenging missions. To compare the 400-mile level-of-effort capability of a naval rail gun to that of a carrier air wing with 27 F-18Es is instructive. In the first eight hours of conflict, a single naval rail gun could deliver twice the payload and three times the energy to ten times as many fixed aim pointsand without hazarding flight crews over hostile territory.6

From the outset, and throughout any conflict, a naval rail gun could combine extended range, sustained rapid fire, and hypersonic projectile velocities to have a devastating impact across the depth and breadth of any future battlefield. In essence, a naval rail gun could embody the extremely accurate and intense delivery of level-of-effort munitions envisioned in The Navy Operational Concept.

Delivering integrated joint fires throughout the battlespace for every type of mission-as foretold in The Navy Operational Concept-requires that naval aviation retain a prominent role in naval power projection. Yet the escalating acquisition and life-cycle costs of manned tactical aircraft render the power projection status quo unsustainable. Unmanned aerial vehicles (UAVs) and uninhabited combat air vehicles (UCAVs) could offer an effective and affordable complement to manned aircraft.

Rapidly escalating cost is only one of many factors that mandate a hard look at alternative aircraft designs. Proliferation of lethal, low-cost, and sophisticated weapons renders future operational environments increasingly hostile to surveillance and strike aircraft. Unmanned aerial vehicles could provide the opportunity to reconnoiter and destroy critical targets before local air superiority is established, and before chemical or biological contamination assessments have been completed. UCAVs and UAVs can perform organic reconnaissance, strike, and lethal suppression of enemy air-defense missions at the earliest stages of hostilities. While not a panacea, increased use of unmanned systems could offer an expanded array of power projection and surveillance options to the joint task force commander and reduce the number of flight crews who would be at risk over hostile territory.

Unmanned air vehicles, however, are not likely to replace manned aircraft. The fog of war will continue to require an adaptable and fully retaskable pilot-in-the-loop in many tactical situations. At issue is just how often the pilot must be in the cockpit.

Elimination of human occupants-plus their life support, mission, and display equipment from the air vehicle, particularly in multiseat aircraft-allows dramatic size reductions, with greater internal volume for fuel, sensors, and weapons. For example, typical UAVs and UCAVs would occupy only one-third of the flight-deck space required for comparable manned systems.


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WRail guns such as this---conceptualized as part of the Strategic Defence Initiative--have devastating destructive power.

UCAV and UAV concepts span the full range of risk and complexity. For maritime applications, however, the need to launch and recover air vehicles from ships mandates development of a vertical takeoff and landing (VTOL) family of unmanned air vehicles. Advances in composite-construction techniques and improvements in jet-engine performance make VTOL strike UCAVs and support UAVs viable and attractive options for naval applications in the 2015-2020 timeframe.

A VTOL strike UCAV would offer an intriguing marriage of tactical aircraft versatility with new levels of employment flexibility. Combining vertical takeoff and landing technology with low life-cycle costs, small size, and precision weapons, this aircraft could be ideally suited for the "3D" missions dirty, dangerous, and dull-that are less desirable for manned aircraft. Conversion of a boneyard AV-8A or a Joint Strike Fighter fly-off platform to a VTOL strike UCAV demonstrator could provide proofof-concept, evaluate shipboard suitability, and pave the way for development of a smaller, purpose-built strike UCAV system.

As emerging technologies resolve the conflicting aerodynamic requirements between vertical-flight and longendurance operations, development of a VTOL support UAV could answer the warfighter's call for near-continuous real-time reconnaissance and precision targeting. Achievable design goals for a maritime-based support UAV include: vertical takeoff and landing capability; 12 hours' endurance on station at 200 miles; and modular sensor and equipment packages, able to handle the bulk of carrier battle group and amphibious ready group surveillance, targeting, and maritime reconnaissance functions-that would include electronic-reconnaissance, maritime-patrol, minereconnaissance, and airborne-early-warning missions.

Development of vertical takeoff and landing strike UCAVs and support UAVs would offer a wealth of revolutionary warfighting applications for maritime forces. A destroyer-based air wing, for example, becomes a real possibility. Adding a flight deck atop the existing helicopter deck on an Arleigh Burke (DDG-5)-class destroyer could provide enough space to operate an air wing of up to 20 strike UCAVs and 5 support UAVs-a significant enhancement to maritime strike, surveillance, and sortie generation capability.

In another twist of the flexible employment theme, integration of VTOL strike UCAVs and support UAVs into a carrier air wing could provide more combat capability and employment flexibility. Today, a typical Nimitz (CVN68)-class carrier air wing consists of 75 manned aircraft. Of these 75 aircraft, 20 are loosely defined as support aircraft. And 36 strike aircraft-out of the 50 strike aircraft on board-typically are mission-ready on the flight deck.

One innovative employment option is to replace the 20 very large, carrier-based support aircraft one-for-one with 20 very small support UAVs. This change alone would yield enough extra space on the flight deck to increase the mission-ready strike aircraft count by 33%, from 36 to 48 aircraft.

Alternatively, the carrier's strike capability could be maximized in one of two different ways-the 20 support UAVs from the previous example could be relocated to other battle group warships and replaced on the carrier with six additional Joint Strike Fighters, increasing the mission-ready strike aircraft count to 54 aircraft. Or, the 20 support UAVs could be replaced one-for-one with VTOL strike UCAVs, bringing the number of missionready aircraft to 63, nearly doubling the strike aircraft availability of the baseline Nimitz-class carrier air wing configuration.

The hallmark of carrier-based tactical aviation is operational flexibility. VTOL strike UCAVs and support UAVs would be a powerful extension of naval aviation capabilities at a fraction of the cost of equivalent manned systems. They potentially extend strike-and-surveillance capability to any ship with a helicopter deck and modest refueling and rearming capability.

Building a Modular Surface Fleet

Coping with the uncertainties of the post-Cold War international environment requires that revolutionary naval fires be complemented by enhanced warship flexibility. The Navy Operational Concept demands that "we put the right force, at the right place, at the right time" to accomplish a given mission. Constructing modular surface combatants would enable future maritime forces to meet a diverse array of operational requirements with tailored capabilities and to allow the incorporation of new technologies without a major overhaul. Modular mission packaging-as opposed to modular construction techniquesallows weapons and electronic systems to be decoupled from hull construction and maintenance cycles, permitting a common hull form to accommodate a number of different mission capabilities.

Operational flexibility in surface combatants is important-but at what cost? Blohm & Voss, a German shipbuilding firm, has shown an 18% saving in life-cycle maintenance costs, through the use of modular weapons and electronics systems.7 Their ability to decouple weapon systems and major electronics systems from their hull also allows a compressed construction cycle, resulting in lower acquisition costs. Blohm & Voss frigates, for example, required a 44-month design and construction cycle-as opposed to the 72-month cycle required for frigates using conventional design techniques.

Cost estimates suggest that constructing a destroyersize modular combatant would result in savings ranging from 11% to 32%-depending on mission tailoring.8 Conversion and upgrading costs are difficult to model, but these savings may be substantial.

Advanced computer-aided design and construction techniques, combined with integrated power, would allow future surface combatants to incorporate modular packages to a much greater extent than even the Blohm & Voss designs. Examples of warfighting capabilities that could be adapted to the modular concept include vertical launch missiles, undersea warfare, fleet air defense (Aegis), and naval surface fire support. Modular packages also could be tailored to accommodate other specialized functions, including support of embarked Marines, special warfare forces, humanitarian assistance, and noncombatant evacuation operations.

Mission-specific modules could be removed when necessary for maintenance, placed on other combatants, or used on shore at specialized training facilities. Except for hull repairs, warships would not require extended overhauls, because specialized mission modules could be repaired and upgraded independent of the hull. Modular surface combatants could facilitate expeditious and costeffective incorporation of technology upgrades, thus avoiding the combatsystem obsolescence that warships now increasingly face soon after delivery.

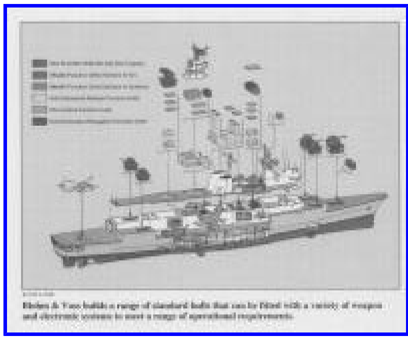
A family of mission-tailorable warships built around a common hull and using modular combat systems would allow operational commanders to optimize a battle group's capabilities, based on anticipated mission requirements. From peacetime presence to major regional conflict, modular warships could bring revolutionary flexibility in upgrades to tomorrow's Navy.

Net-Based Undersea Warfare

Flexible combat power projection requires strong force protection. The Navy Operational Concept demands that future naval forces have the "ability to dominate the littorals, including the undersea environment"-a major challenge, considering the proliferation of sea mines and increasingly sophisticated submarines that will confront U.S. naval forces.

Technological dominance in undersea warfare is imperative for U.S. naval forces to ensure access and maintain local maritime superiority in regions of the world where vital interests are threatened. Near-acoustic parity at low-radiated-noise levels will be the norm, as future undersea targets challenge the effectiveness of each element of the undersea warfare system. A net-based undersea warfare system-with the capability to merge data from a variety of dispersed acoustic and nonacoustic sensors into a single, more powerful sensor array-will be an essential force multiplier, consolidating planned improvements in sensors, weapons, and processing ability.

The slower pace of undersea warfare may not require the degree of detail and speed of sensor data sharing found in the Aegis-driven cooperative engagement capability (CEC). Nonetheless, the ability to process images jointly, along with data collected from dispersed sensors-and then to merge these data to generate an accurate, real-time track of a threat submarine-could represent a powerful increase in undersea warfare capability. System effectiveness, however, will depend on complete interconnectivity with the joint task force command organization.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Blohm & Voss builds a range of standard hulls that can be fitted with a variety of weapon and electronic systems to meet a range of onerational re uirements.

A key challenge is to determine the appropriate communications path linking the undersea network to the multitiered joint communications architecture. Options include: integrating the net-based undersea warfare system into the existing CEC architecture; merging into Link 16; or constructing a separate network to knit together dispersed platforms and sensors that will enrich the tactical picture. Each of these options has advantages and drawbacks. A series of initial tests could evaluate each option, determine appropriate net-based undersea warfare system performance requirements, and specify the most cost-effective communications configuration.

An essential component of the net-based undersea warfare system is improved submarine and unmanned underwater vehicle connectivity at operational speeds and depths. One promising example of new technology allows high-data-rate, two-way communications, through a traditional buoyant cable antenna. This improved capability employs a floating wire antenna that deploys from an attack submarine and uses fiberoptics and multiple antenna modules within the array to improve connectivity.

Linking undersea warfare sensors could have significant operational implications, including the capability to derive a common tactical battle-space picture. Developed in real-time and integrating bottom topographical and environmental data, an integrated tactical display could revolutionize a commander's ability to attain and maintain situational awareness during undersea warfare operations-and to facilitate faster engagement decisions. Automatic, synchronized integration of active acoustic data with other sensor data-such as radar, passive sonar, and electronic-surveillance-measures information-could reduce the number of false contacts and further clarify the tactical picture.

A net-based undersea warfare system also would improve the capability of naval forces to conduct successful undersea warfare operations in the broadest sense, including clandestine mine reconnaissance and neutralization. Employed with submarine- and surface-launched semiautonomous mine reconnaissance systems and mine-hunting unmanned aerial vehicles, the net-based undersea warfare system could operate without local air superiority to neutralize mines before they can threaten naval forces.

Development of a net-based undersea warfare system that capitalizes on current research, incorporates multisource contact management techniques, improves the situational awareness of the tactical commander, and also minimizes time to engagement could ensure local maritime superiority-both in the littorals and in open-ocean operating environments-and lessen the threat of enemy mines and submarines.

Embracing Innovation

Bringing innovations like those described above to fruition is difficult. Innovation requires time, tenacity, openness to new ideas, and a commitment to engage every mind in the organization. Walter Lippman once editorialized that "revolutions are always the work of a conscious minority." Cultivating an ethos in the officer corps to vigorously challenge the status quo, rigorously pursue promising innovations, tolerate failure, and accept constant change as the new norm will strengthen our profession and nurture a culture that embraces innovation.

Innovation may not be inexpensive. After all, past naval innovations-such as the aircraft carrier, submarinelaunched ballistic missile, and Tomahawk cruise missilewere not cheap. But each of these programs was initiated during a period of constrained defense budgets. And each helped U.S. forces to fight more quickly, more effectively, and with fewer casualties.

Because innovation inherently involves risks, a researchand-development strategy that mitigates the technical risks, assesses the value added to the warfighter through operational experiments, and expeditiously moves promising ideas from the lab to the fleet is critical to maintaining the qualitative edge of U.S. armed forces. Characterized by solid physics, manageable risk, and affordable high payoff, innovations such as rail guns, unmanned air vehicles, modular surface combatants, and a net-based undersea warfare system are examples of the new thinking required in the interwar years.

[Reference]

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4For all references to The Navy Operational Concept, see Department of the Navy, The Navy Operational Concept (Washington, DC: Government Printing Office, 1997). '5ee H. D. Fair, "Electromagnetic Launch: A Review of the U.S. National Program" Magnetics 33, no. 1 (January 1997), pp. 11-16. 6Analysis from "The Long Range Hypervelocity Gun Analysis" performed at Sandia National Laboratories. 7Blohm & Voss delivered their first modular frigate, the MEKO 360 HI, to Nigeria, and has built modular combatants and electronics systems for seven foreign navies. 8Cost savings estimates derived from preliminary studies by NSWC Carderock Division.

[Author note]

Captain Carman is a naval aviator who has commanded Patrol Squadron Ten and Patrol Wing Ten. His previous staff assignments include serving as assistant national security adviser to Vice President Dan Quayle and Vice President Al Gore and as aide/flag secretary to Commander Carrier Group Six. Colonel Triplett is a naval aviator who has commanded Marine Attack Squadron 223 (VMA-223) and served in VMA542, VMA-331, VMAT-203, VMAT-102, and HMA-269. Prior staff assignments include Chief of Contingency Plans in J-3 U.S. European Command, Stuttgart, Germany. Commander Nault is the prospective commanding officer of the USS Toledo (SSN-769) and has served as the executive officer of the USS Boston (SSN-703). He has served on the operations staff of Commander Carrier Group Six. Commander Bartlett is a naval aviator serving with the Current Operations Directorate of the Joint Special Operations Command. He spent three tours flying the FIA-18 Homet, and flew 33 combat sorties in Operation Desert Storm. Lieutenant Adams is a submarine officer who has served as reactor controls assistant, damage control assistant, and assistant engineer on board the USS Tennessee (SSBN-734). He is pursuing a graduate degree in national security affairs at the Naval Postgraduate School and is the 1997 winner of the Naval Institute's Arleigh Burke Essay Contest.